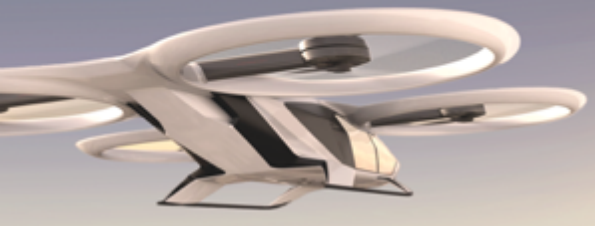

Methodology and first Results for an Urban Air Mobility System in Hamburg

Lufthansa Systems – Autonomous Flight – Proof of Concept, 29. October 2020

Univ. Prof. Dr.-Ing. Volker Gollnick, DLR Institute of Air Transportation Systems and Hamburg University of Technology

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Overview

1. Urban Air Mobility – Key Questions
2. Basics and Definitions
3. The Methodology
4. Demand and expected Traffic
5. Airspace capacity and structure
6. Summary

A collaborative Projekt of the institute with German Aerospace Center

ILT Institut für Lufttransportsysteme

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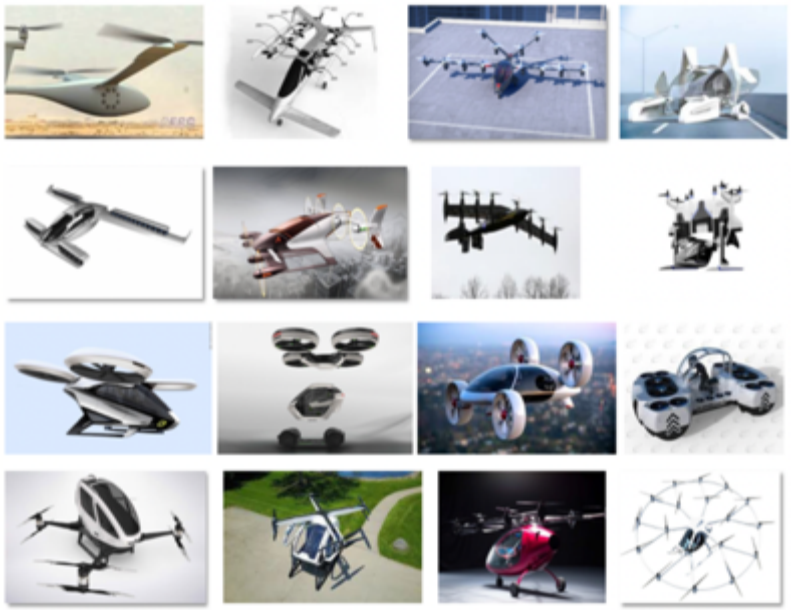
Urban Air Mobility – Some Key Questions



Many vehicle ideas and concepts!

Many Questions

- Manned – Unmanned ?
- Passenger – Cargo?
- Scheduled – Unscheduled?
- Inspection – Transport – Surveillance?
- Acceptance?
- What is it good for? –
- …

Where to start?

Urban Air Mobility – Some Key Questions

- Which ***method*** provides a resilient feasibility proof of urban air mobility concepts?
- What kind of ***demand*** can be expected?
- How may principle ***air traffic architectures*** look like in urban environments?
- Which ***infrastructures*** in terms of ***landing areas*** but also ***guidance, navigation, command and control*** *systems* are needed to operate such urban air vehicles?
- How may ***flight routes*** and ***networks*** look like?
- What is the ***societal impact*** or under which conditions such concepts could be accepted?
- What are the ***added value*** *and* ***potential cost***?

Urban Air Mobility – All Questions answered?

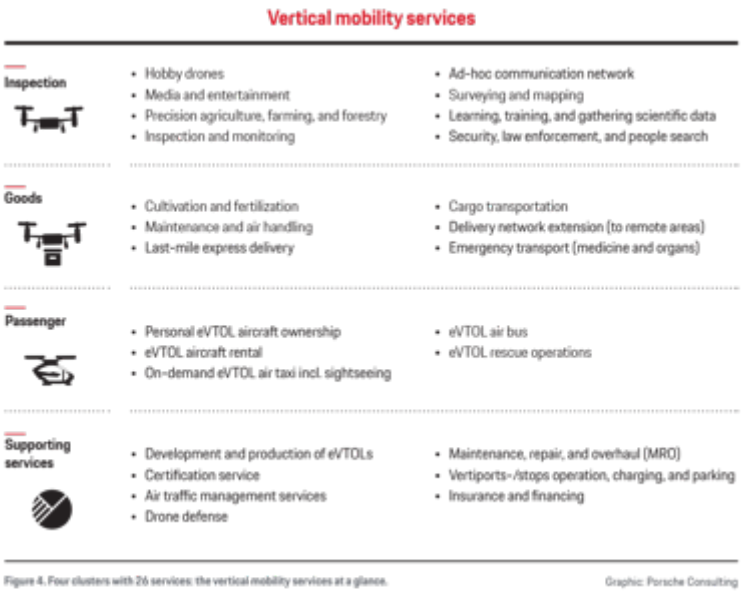
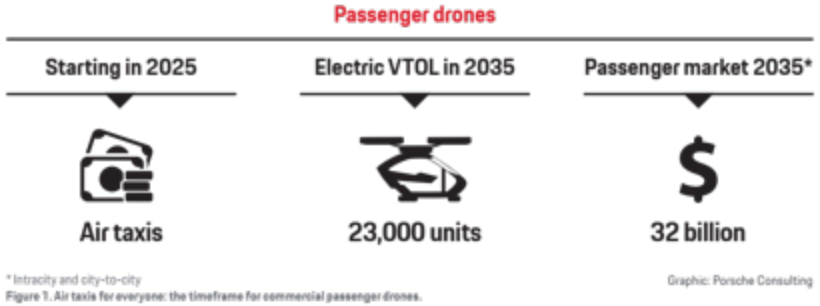


Figure 4. Four clusters with 26 services: the vertical mobility services at a glance. Graphic: Porsche Consulting



* Intracity and city-to-city

Figure 1. Air taxis for everyone: the timeframe for commercial passenger drones. Graphic: Porsche Consulting

One Example: The Future of Vertical Mobility – A Porsche Consulting Study, 2017

There are many more or less qualitative consultancy studies indicating a big market!

Urban Air Mobility – Some Definitions

What is **Urban Air Mobility**?
A **first** Definition: Urban Air Mobility covers **Drones and Air Taxis**

	Passenger-transport	Cargo-transport	Special Operations
Manned (Pilot)	**X**	**X**	**X**
Unmanned	**X**	**X**	**X**

What is **Urban Area**?
A **second** Definition: Urban Area is **more than a city**, some districts, some counties, some states, larger area, …

	Metropolitan Region Los Angeles	Metropolitan Region Hamburg	Metropolitan Region "Ruhr" Area
Inhabitants: City area/region	4.0/13.3 Mio	1,9/5,3 Mio	5 Mio.
Population density:	3.273 people/km²	2430 people/km²	1136 people/km²
Area city / area	1.290,6 km² / 12.561 km²	ca. 755 km² / 28.500 km²	- /4.400 km²
Districts/local countries	15 districts	4 states	4 counties/ 11 cities

Urban Air Mobility – Some Definitions

What is the level of **Automation**?

A **third** Definition: Level of Automation by the German Ethical Council (2017)

No irreversible responsibility of systems allowed!

Level of Automation	Characteristics
Level 0: Pilot Only	Pilot controls the entire vehicle and operation, no assisting, supporting system functions
Lvel 1: Assisted Piloting	Pilot controls the vehicle, systems support stability and provide information about vehicle and operational states
Level 2: Partly Automated Piloting	Pilot supervises permanently automated systems vehicle control and operational modes
Level 3: Highly Automated	Fully automated operations with spot check supervision of the pilot
Level 4: Fully Automated	**Pilot monitors the entire flight operation of the vehicle system only**
Level 5: Pilotless Flight	No Pilot; the vehicle is fully responsible of the flight mission and all decisions

Urban Air Mobility is about Automation NOT Autonomy!

Urban Air Mobility – Some Definitions

The „Ruhr"-Area

The „Los Angeles "-Area

Common characteristics:

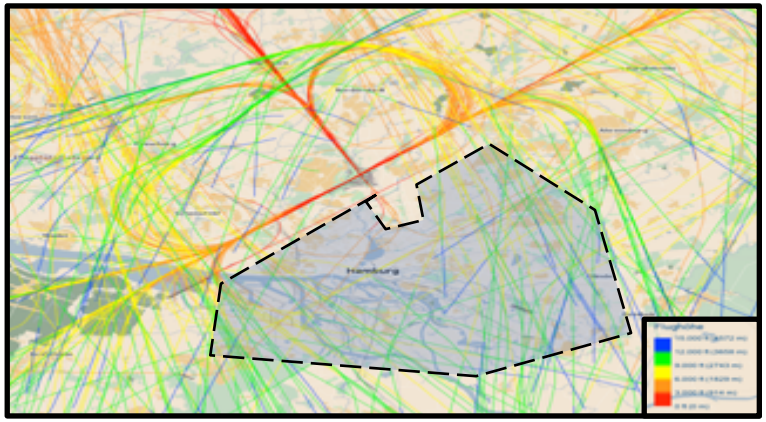
- About **150 km from center**
- About **300 km extension**
- **5 – 13 million people in the area**

The Hamburg-Metropolitan"-Area

Hamburg Metropolitan Region is a predestined use case!

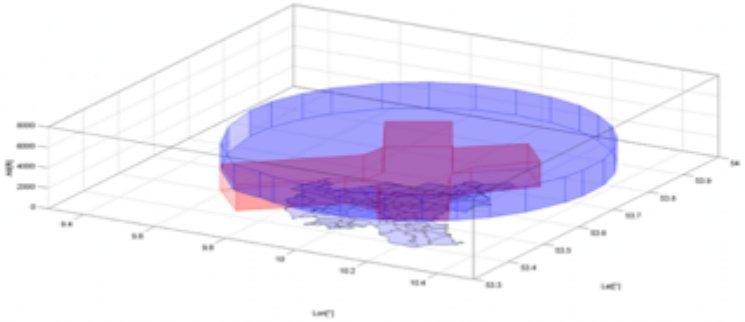
Urban Air Mobility – Special Conditions

Reasons and hurdles to use urban air vehicles



Fuhlsbüttel Flight Tracks – City Area Coverage

Hamburg Elbe River



Fuhlsbüttel Control Area

- **Natural boundaries**, like rivers, hills
- **Areal constraints** like city airports
- Exentsive **ground** traffic **capacity limits**

Hamburg Metropolitan Region is a predestined use case!

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The Methodology – From logical considerations to a holistic system model

Major elements and interdependicies for the methodology being identified are:

- Urban data (topology, population distribution, income distribution, et.al.)
- Airspace concepts and architectures
- Operating concepts
- Vertiport concepts and integration
- Trajectory simulation and traffic routes
- Flight planning and de-conflicting

System modeling:

- DLR Remote Component Environement (RCE)
- DLR Common Parametric ATS Configuration Scheme (CPACS)
- Setup of Model Chain
- From rough to detailed

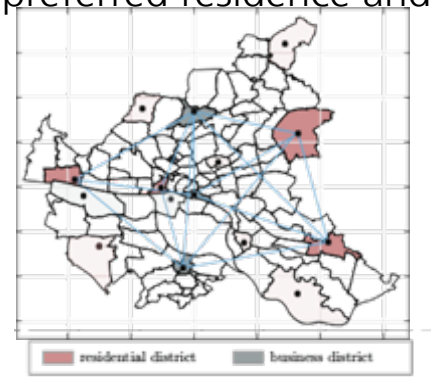
Demand and expected air traffic

Assuming:

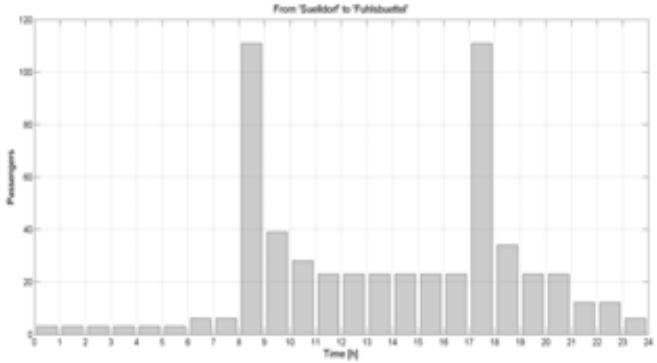
1% of daily commuter in the Hamburg area might use air taxi:

~ 5000 people/day ≈ 10000 (forth and back) air movements for single use

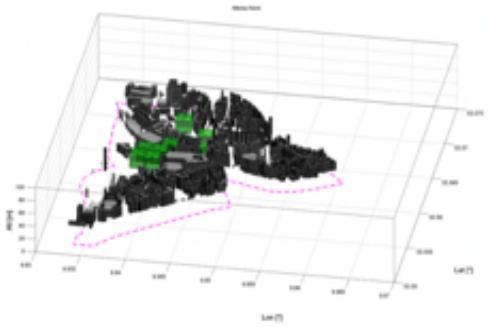
There are preferred residence and business areas, which behave like sinks and sources



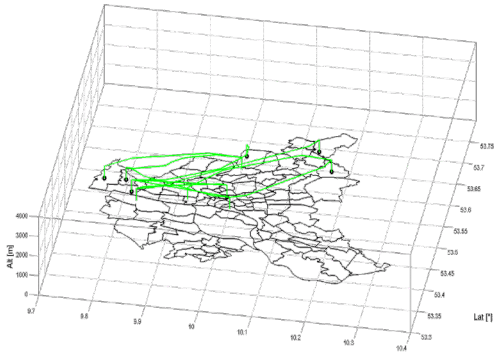
Exemplary Residence and Business Areas



Daily distributed demand



Exemplary Vertiport allocation in „Altona-Nord“



Resulting first network structure

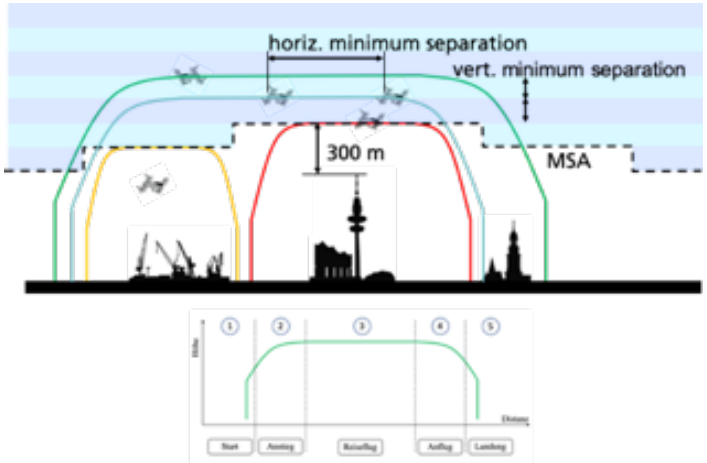
Capacity estimation and Air Space structure

Overall capacity is shared by air taxis, commercial air vehicles, drones

$$CAP_{airHH} = CAP_{airCom} + CAP_{airTaxi} + CAP_{airDrones} \quad (1)$$

Urban Airspace is considered as **separated and separately controlled** from other airspaces

Obstacle clearance 300 m, max speed 300 km/h (83 m/s)
Upper Limit 2500ft to avoid airspace „C“



Proposed airspace structure

- Setup of a new, **complementary Urban Air Traffic Management System** combining VFR and IFR features
- Introduction of new **highly automated flight rules**, adapted to urban air vehicle using new services/technologies
  - **De-conflicted 4D-route planning**
  - **Adapted separation minima**
  - Indepency of **most weather conditions**
  - Real time data **communication** also using **mobile radio (5G)**
  - Satellite based real time **surveillance**

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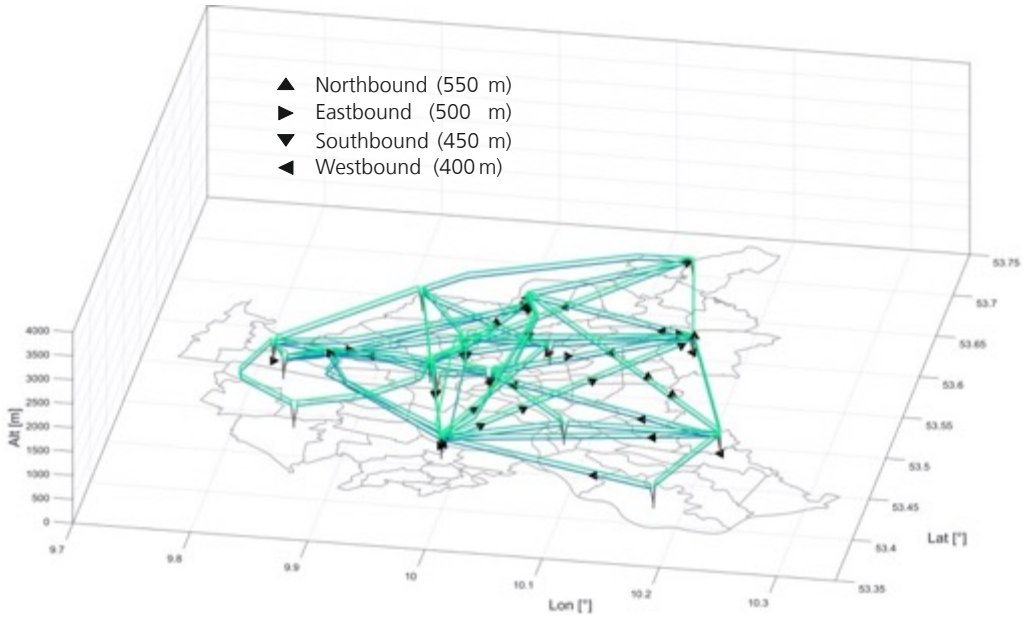
Capacity estimation and Air Space structure

A first result for an air network structure



		horizontal separation		
		3 nm	1000 m	**500 m**
vertical separation	300m	24	755	3020
	100m	72	2265	9060
	60m	144	4530	**18120**

Potential Hamburg urban airspace capacities (spped adapted to seapration (max. 300 km/h)

Actually about 450 – 500 official flights over Hamburg per day

A **four level airspace structure** proposal to host urban air mobility demand oriented in Hamburg

- Up to 18000 movements possible at the same time (drones and air taxis)
- Adaption of speed for flight in urban obstacle area needed

Is there demand and acceptance for it?
What are the infrastructural cost (vertiports, guidance systems?

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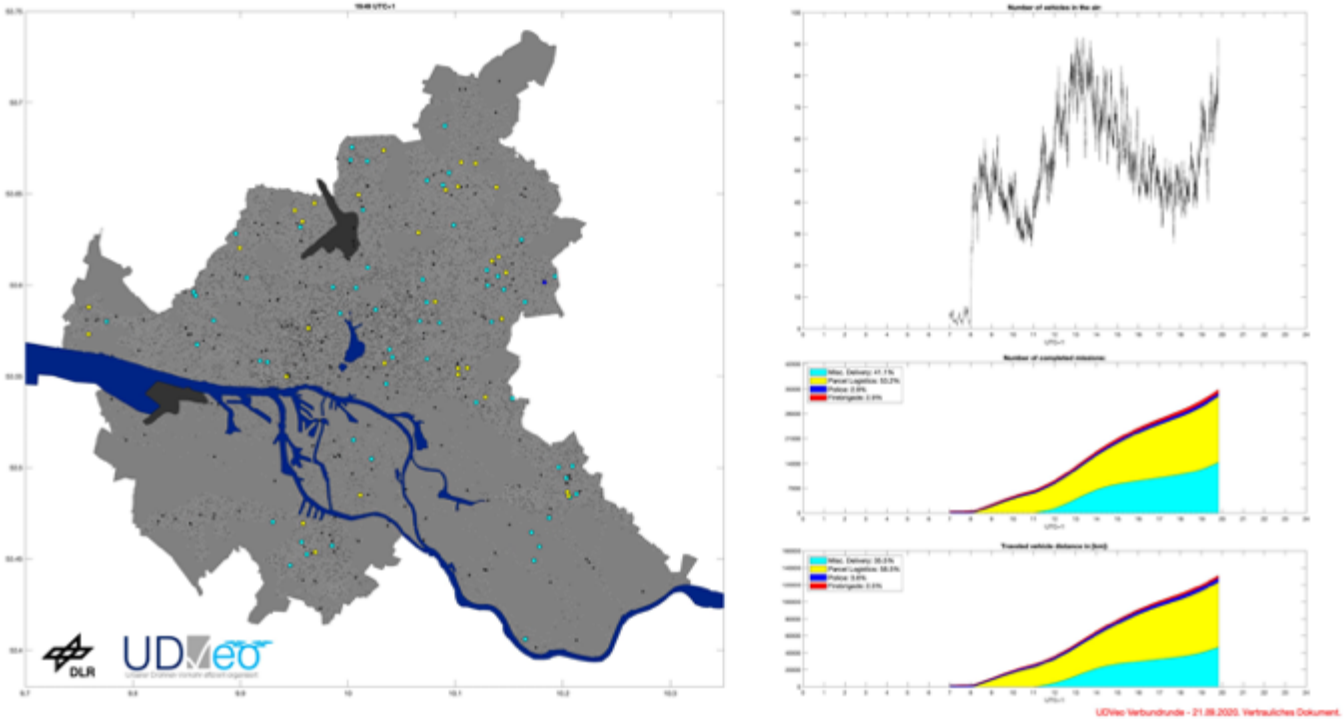
Capacity estimation and Air Space structure

A first result of max. 80 flight vehicles



- Police-, Medical-, Fire fighter services represent only a very minor share of operations!
- Parcel and Taxi services are dominand

Depending on societal, governmental and industrial interest consensus based operational concepts will be developed

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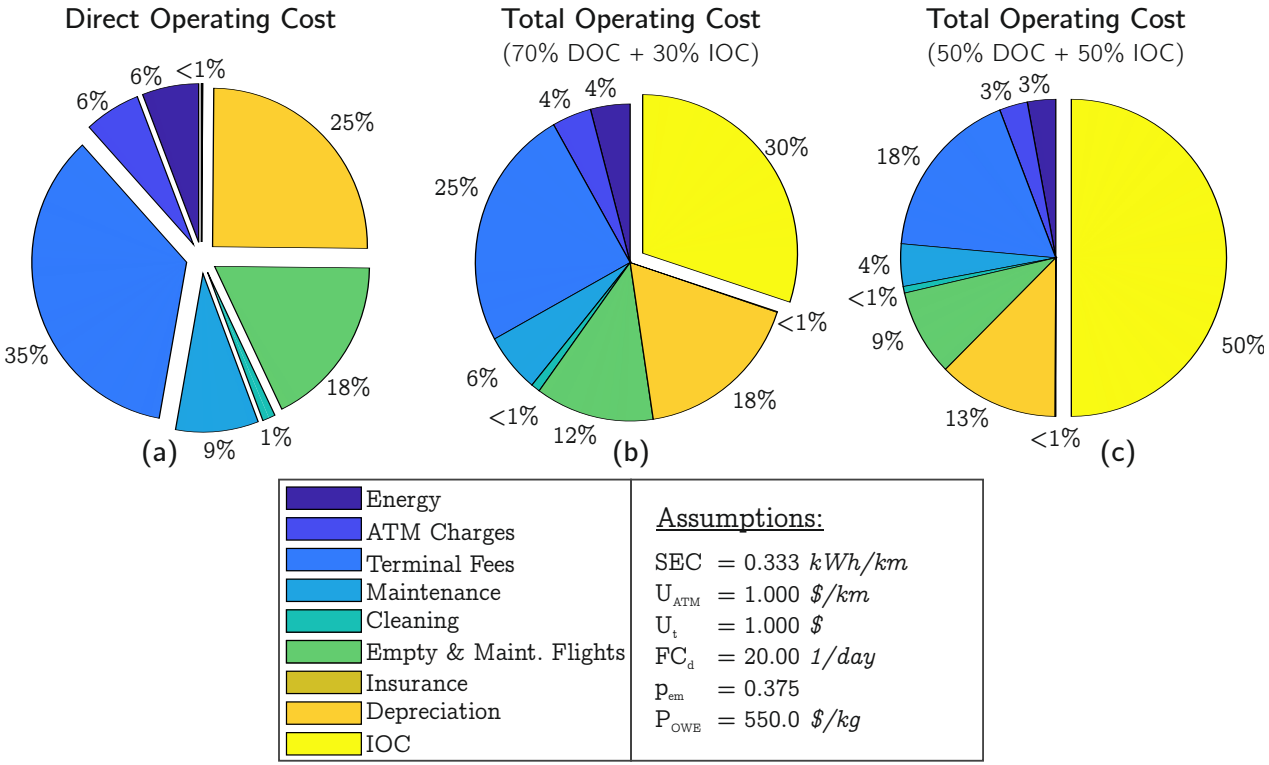
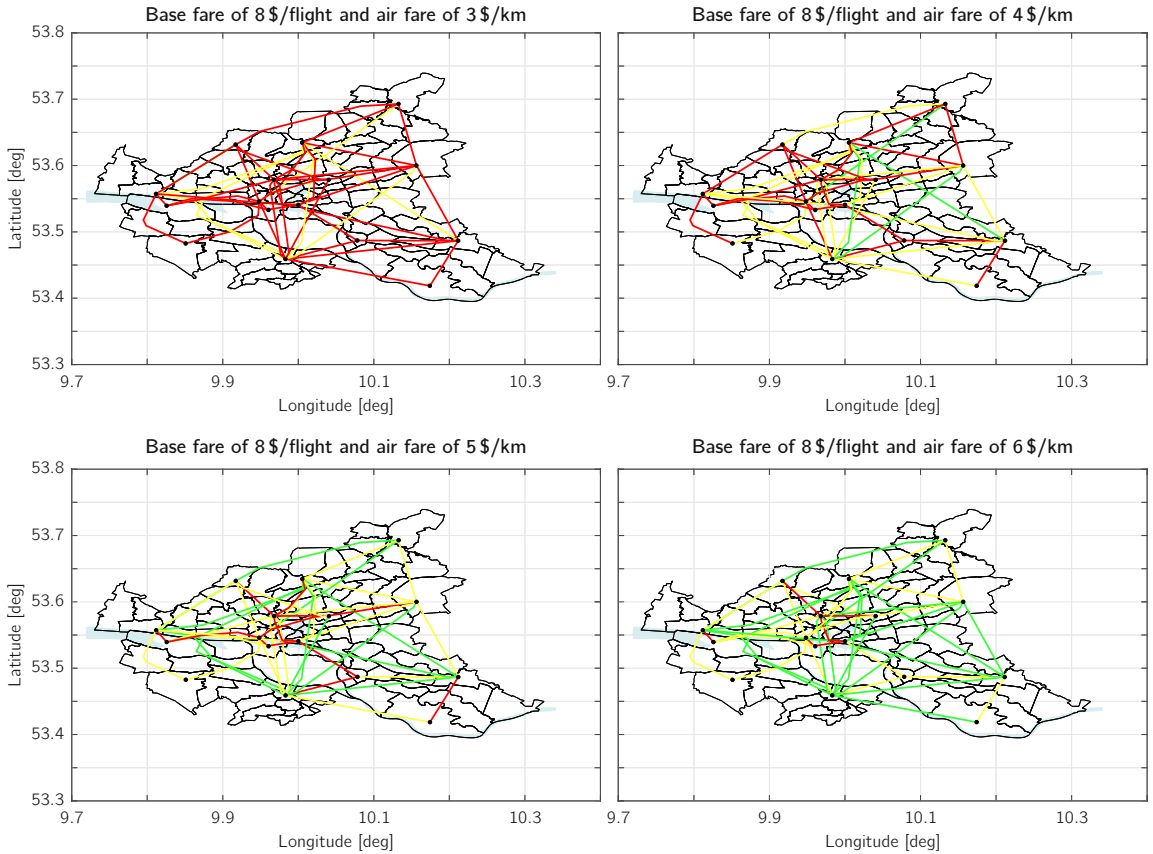
What about cost and revenue?



Based on published cost estimations including taxi and commercial operations a first cost model has been established.

More precise cost estimation depends on infrastructure and vehicle designs

What about cost and revenue?



A **taxi fares** based **revenue model** has been chosen

Fixed base fare ($8) plus **varying** kilometer **fare** ($3-6)

Due to more direct tracks, **shorter distances** are possible, **limiting** the overall **fares**.

Approximately 30 - 50% **shorter tracks possible** compared to ground taxis

Many OD pairs can be operated profitable!

Summary

- Urban Air Mobility covers **Air Taxis** and **Drone** applications
- **Hamburg** is a predestined **Use case** and German „Model City“

- The DLR **Institute of Air Transportation Systems** and TU Hamburg have the **holistic capability and model system** available to design, simulate and analyse the **feasibility, acceptance and added value**
  - **Demand modelling** on **district level** and **transport knots**
  - Sufficient **Air space capacity for Urban Air Mobility in Hamburg available**
  - **First concept proposals for realsisation developed for metropolitan region Hamburg**
  - **Automated flight planning and de-conflicting algorithms** available
  - First **Cost and revenue models** avaliable
- **Societal acceptance** will be focus in the Hamburg iLUM project, started yesterday

- **Balanced system design between societal, political and industrial interest** is key for success

Excited?

aerospace

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Concept Paper

A Collaborative Approach for an Integrated Modeling of Urban Air Transportation Systems

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Institute of Air Transportation Systems of DLR at TUHH

The architectural holistic concept for Urban Air Mobility in Hamburg

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